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Factorial design for preparing chitosan nanoparticles and its use for loading and controlled release of indole-3-acetic acid with effect on hydroponic lettuce crops (Article)

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Abstract

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The excessive use of agrochemicals generates damage to the environment, so their controlled release from biodegradable nanoparticles represents a good solution. In this study, chitosan nanoparticles (CNPs) were prepared by ionic gelation with sodium tripolyphosphate (TPP), according to a 2^4 factorial design to evaluate the effect of different factors (chitosan amount, TPP amount, agitation speed, and agitation time) influencing the nanoparticle size (NPS) and the polydispersity index (PDI). Once established the proper conditions by the factorial design, CNPs were prepared and loaded with indole-3-acetic acid (CNP-IAA). The nanoparticles loaded with chitosan:IAA mass ratio equal to 1:0.25, showed the higher loading capacity, thus were then used for the release tests and hydroponic lettuces crops. The analysis by dynamic light scattering (DLS) reveals a mean diameter for CNPs and CNP-IAA of ~149 and ~183 nm, respectively. Moreover, further characterization by thermogravimetric analysis, Fourier transform infrared spectroscopy and scanning electron microscopy, indicates that nanoparticles were effectively loaded with IAA. In addition, the release assays results were adjusted to the Korsmeyers-Peppas mathematical model, showing that 100% of the hormone is released in about 48 h. Also, the model fitting suggests that the release process is carried out in two steps: the first of releasing by diffusion followed by a second of sustained-release. Accordingly, our results prove that CNPs-IAA applied to the hydroponic crop of the Crocantela variety crisp lettuce (Latuca sativa L.), have a beneficial effect on the plant growth producing an increase of 30.9% in the number of lettuce leaves. © 2020 Elsevier Ltd

Author keywords

Chitosan | Factorial design | Hydroponics | Indole-3-acetic acid | Nanoparticles

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In the IAA IR spectrum, a characteristic ? (N?H) intense band is observed at 3381 cm?1; an intense stretching band of ? (C[dbnd]O) is observed at 1687 cm?1, corresponding to the carboxyl group; a sharp peak is observed at 3160 cm?1, corresponding to ? (NH) and peaks at 1722 cm?1 and 2854 cm?1 belongs to ? (C[dbnd]O) and ? (C?H), respectively. Also, multiple peaks corresponding to the ? (C[dbnd]C) of the indolic environment, appear at ~1290 cm?1 (Sharma et al., 2019). On the other hand, the CNP spectrum shows the 3400 cm?1 widened band, corresponding to the ? (OH) present in the chitosan structure. It also indicates the possibility of hydrogen bond formation between tripolyphosphate oxygen and chitosan amino group hydrogens. Moreover, the 1548 cm?1 and 1400 cm?1 peaks are

probably formed because of the NH2 groups protonation -that are now NH3+ ions-, and the hydrogen bridge bond formation between the O-TPP and the H of the free amino groups. The presence of the 1022 cm?1 peak is because...
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